# THE EFFECTS OF SURFACE FILMS ON THE RATE OF TRANSPIRATION: EXPERIMENTS WITH POTTED POTATOES

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In a previous report[1] we have presented data which is believed to justify the conclusion that an application of a surface film of Bordeaux mixture to the leaves of the castor bean or the tomato increases materially the rate of transpiration. The importance of a careful determination of various physiological effects of this spray mixture was suggested primarily by the increased vitality and yield exhibited by potatoes (*Solanum tuberosum*) treated with this fungicide during seasons when fungi and insects were unimportant factors. In our previous experiments the potato was not included, and it seemed most important, as a next step, to ascertain the effects of certain sprays upon the transpiration of this plant.

Experience has demonstrated that the potato may not be used satisfactorily in potometer experiments. Moreover, it was desired to arrange the experiment so that the transpiration quantities obtained might represent an interval of a week or more. On the other hand, it had been found as a result of our previous work with potted tomatoes that a very considerable amount of labor is required when it becomes necessary to add measured quantities of water every day to a series of fifty or more potted plants. Accordingly, for this and for other work proposed, a method was devised whereby we were able to employ a self-watering device based on a principle often used in the laboratory.

[1] Duggar, B. M., and Cooley, J. S. The effect of surface films and dusts on the rate of transpiration. Ann. Mo. Bot. Gard. **1**:1–22. *pl. 1*. 1914.

The apparatus is shown in pl. 18. The rack, or support, is made of a single sheet of galvanized iron 18 cm. wide and 55 cm. long, these dimensions being adequate for a stand 33 cm. high. Besides cutting a hole in the upper part for the insertion of the neck of the bottle, the operation of making a stand will be clear from the plate and involves merely a few slits with the shears, the balance being accomplished by bending. Two or four rivets may be used if additional strength is required. With regard to other features of the apparatus it is well to note that (1) the shoulder of the flower pot rests on the rim of a tin cup somewhat deeper than the pot, the latter containing the immediate supply of water; (2) there is an inverted bottle with a capacity of about 1500 cc. serving as a reservoir of water and aspirator; and (3) the bottle is connected with the cup by glass and rubber tubing.

In setting up an experiment the exposed area of the pot (above the shoulder) and the soil are covered with paraffin or parawax; the cup is filled with water to such height that when the pot is inserted the water will rise to the height of about 2 cm. on the side of the pot, thus insuring adequate absorption; while a notch in the side of the cup makes it possible to introduce the rubber tube connecting with the bottle, this tube being adjusted to reach just below the new level of water in the cup. With a tube of proper diameter, the water level in the cup is kept practically constant so long as the bottle contains water. This apparatus, complete, may be quickly and sufficiently accurately weighed on the Troemner scales. To prevent upsetting, after arranging in the experimental area, it is well to make the stand secure by providing a small hole in the base, through which a bamboo stick may be thrust into the soil. To this stake, also, for further support, the bottle may be fastened by cord or rubber band.

The device above described has saved much time and has enabled us to obtain a soil moisture content practically uniform in all the pots used in the experiment. It possesses the disadvantage of tending to maintain a moisture content which for long-term cultures is too high for the best growth of the potato. A slight modification of the method would seem to be practicable in several aspects of transpiration work.

Three weeks before the experiment began the plants were repotted, new 5-inch pots of good quality being used, and at the time of the installation of the experiment the drainage holes in the pots were carefully corked, so that all transfer of water would be through the porous walls. The potato plants employed were grown in the greenhouse during the early spring, but on April 20, about two weeks before the test was made, they were placed outside, to insure hardiness. When used, the plants were from 25 to 45 cm. high, each plant with from about 15 to 30 leaves. Some plants were blossoming, and tubers were forming.

The experiment embraced 7 series, or lots, of 10 plants each, sprayed with mixtures as follows: (1) strong Bordeaux, (2) control, no spray, (3) weak Bordeaux, (4) lime wash, (5) lime sulfur, (6) strong Bordeaux and lampblack, and (7) lime wash and lampblack. The strong Bordeaux (designated hereafter Bordeaux) contained 12 grams $CuSO_4$ and 14.4 grams CaO per liter of water, being approximately the 5–6–50 formula of agricultural practise. It was made up in the usual way. The weak Bordeaux was one-half the strength of the stronger mixture. The lime wash was a $Ca(OH)_2$ suspension consisting of 60 grams of CaO per liter of water. A commercial preparation of lime sulfur was used, and this was diluted, as usual, to about 1–25. The Bordeaux-lampblack and the lime-wash-lampblack preparations were made by rubbing into small quantities of the Bordeaux and lime wash 5 and 10 grams respectively of lampblack, then diluting to one liter.

The method of selecting the plants for the different lots was precisely that described in the previous report, that is, selecting at one time 7 plants (as many as there were lots) between which there could be little or no choice, and distributing these at random, 1 to each lot until each included 10 plants. All plants (except controls) were sprayed on May 5, but a rain that night, before protection was provided, necessitated respraying the following day. After spraying, the plants were placed on the stands and each connected with its water supply. They were arranged on an exposed lawn, each lot occupying a row, with the plants 4 feet apart. Moreover, several rows of potted potatoes were arranged around the entire area in order that all

plants in the experimental area might have equal exposure. Over the experimental plot a frame was provided, so that the whole area might be protected by tarpaulins in case of rain. Fortunately, however, no rain occurred during the period of the experiment.

After a preliminary exposure of 24 hours, which enabled us to determine that the 70 plants of the experimental area were in good condition, the initial weighings were made. A definite order was established, this being crosswise of the different lots. The same order was observed at the close of the period, and similarly in the second period a consistent scheme was followed, in order that the time interval might be as uniform as possible. After the weighings at the close of the first period, all plants were discarded which showed any signs of weakness or injury arising from the conditions of the experiment. It should be stated, too, that these conditions were taxing. The weather was bright and warm, the pots were severely exposed, and, as already noted, the water content of the pots was necessarily fairly high. With the plants remaining in a condition apparently normal and vigorous from the first period, a second "run" was made, the latter including from 4 to 7 plants in

TABLE SHOWING WATER LOSS AND GREEN WEIGHT OF THE PLANTS

| Lot | Film covering | 1st period, May 6–11, 10 plants | | | 2nd period, May 11–15, 7 plants | | |
|---|---|---|---|---|---|---|---|
| | | Ave. water loss per plant | Ave. green weight per plant | Water loss per g., green weight | Ave. water loss per plant | Ave. green weight per plant | Water loss per g., green weight |
| 1 | Bordeaux, strong | 526.6 | 50.3 | 10.46 | 463.3 | 55.0 | 8.42 |
| 2 | Control | 413.8 | 61.0 | 6.78 | 433.3 | 63.1 | 6.86 |
| 3 | Bordeaux, weak | 642.4 | 60.9 | 10.54 | 574.0 | 61.7 | 9.30 |
| 4 | Lime wash | 584.5 | 70.7 | 8.27 | 613.6 | 76.3 | 8.04 |
| 5 | Lime sulfur | 443.0 | 62.8 | 7.06 | 450.7 | 70.0 | 6.44 |
| 6 | Bordeaux and lampblack | 792.1 | 66.1 | 11.97 | 653.0 | 75.2 | 8.69 |
| 7 | Lime and lampblack | 596.6 | 58.3 | 10.20 | 585.6 | 66.8 | 8.78 |

each lot. In selecting plants for this second period, the size factor was again taken into consideration, as far as possible.

More stress should, however, be laid upon the data from the first period. The green weights of the plants discarded at the close of the first period were taken immediately, while those plants used in the second period could not be weighed until the close of that interval. This small interval of time, however, could cause no material change in the weights. In the accompanying table there are given in grams the average water loss per plant, the average green weight per plant, and the water loss per gram of green matter.

From the data exhibited it is obvious that with potted potatoes, as with castor bean leaves and potted tomatoes in our earlier experiments, there is a marked acceleration of transpiration induced by spraying with Bordeaux mixture, as also with some other films. Of the several films employed, lime sulfur alone yields an average water loss comparable with that of unsprayed plants. Of all lots showing increased transpiration those treated with weak Bordeaux and lime wash were in some respects most satisfactory, inasmuch as the plants used, like those in the control, were, in general, in very good condition throughout the period of the experiment. On the other hand, those treated with the stronger Bordeaux, the Bordeaux and lampblack, and the lime and lampblack gave, towards the close of the periods, evidences of the injurious effects of the increased transpiration (apparently) upon the vitality of the plants. These statements may not seem to be in entire accord with the figures presented, for during the second period of the experiment, for example, the transpiration quantity is relatively greatest in the case of those plants sprayed with weak Bordeaux mixture. Nevertheless, our observations enabled us to predict that certain lots, especially numbers 1 and 6, would give in the second period, particularly, transpiration values less than might be anticipated. The smaller quantities in the lots referred to, as contrasted with the weak Bordeaux, are to be explained, in fact, as a direct result of incipient wilting and slight injury, brought about by the higher transpiration capacity induced under conditions already accentuating transpiration.

It is believed, in the first place, that the experiments here reported confirm our earlier conclusion, namely, that a film of Bordeaux mixture facilitates water loss; but, in the second place,

treatment with a fairly thick lime wash or lime wash and lampblack also increases the transpiration rates, the latter more than the former. Lampblack added to Bordeaux seems also to give a higher rate than the Bordeaux alone. It is to be emphasized, however, that the strength of the lime wash employed is four times as great as the lime in the stronger Bordeaux mixture; likewise, more lampblack is used with the lime wash than with the Bordeaux. It seems to be definitely established that certain specific characters of the film are important, but these results suggest, further, that the additional quality of color is a factor requiring consideration. The fact that injury may result from the accelerated transpiration induced by a heavy film of Bordeaux under the conditions of our experiment does not mean that under normal conditions of growth in the field a benefit may not accrue to certain plants—from factors associated with a high transpiration rate.

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## Explanation of Plate

### PLATE 18

View of the apparatus (with tomato plant) by means of which watering was automatically controlled. It has been found convenient to have both stand and cup painted green. For description see text, p. 322.